Chapter 11. Radio Frequency (RF) and Microwave Safety.

11-1. DA Limits.

The DOD and DA, in DODI 6055.11, have adopted the IEEE C95.1-1991, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency (RF) Electromagnetic Fields, 3 kHz to 300 GHz maximum permissible exposure to RF levels. The guiding principle is that no practice shall be adopted or operation conducted involving planned exposure to RF levels in excess of the applicable Permissible Exposure Limit (PEL).

11-2. USACE Limits.

USACE, in compliance with DODI 6055.11, has adopted the IEEE maximum permissible exposure levels for a controlled area. These PELs are presented in Table 11-1. Maximum PEL's for uncontrolled environments are presented in Table 11-2.

11-3. OSHA Regulations.

OSHA set a radiation protection guide for non-ionizing radiation, including electromagnetic radiation. The radiation protection guide is a level of radiation which should not be exceeded without careful consideration of the reasons for doing so. The OSHA radiation protection guide is 10 mW/cm^2 (milliwatts/square centimeter) power density averaged over six minutes, or 1 mW-hr/cm^2 energy density averaged over 6 minutes.

OSHA also requires that a standard radio frequency radiation hazard sign be used to notify employees of possible exposure.

11-4. General Guidance.

a. As with all radiation, only personnel who have been trained in the safe use of the equipment should work with the equipment. Similarly, only trained personnel, using calibrated instrumentation, should be used to assess, survey or evaluate non-ionizing radiation fields, personnel exposures and control measure determinations.

b. NOTE: Non-ionizing radiation TLVs may not protect against electromagnetic interference with cardiac pacemakers. Persons wearing pacemakers should check the manufacturer's literature to ensure TLVs are adequate to avoid interference.

c. The basic dosimetric parameter for RF exposure is the Specific Absorption Rate (SAR). The SAR of 0.4 watts per kilogram has been set as the maximum exposure for humans. This is a factor of 10 below the level of exposure determined to potentially cause deleterious effects in humans.

The PELs are listed in terms of measurable field parameters that act as a convenient correlation to the SAR.

d. There are exceptions to the listed PELs for certain exposures and situations. These are listed in DODI 6055.

11-5. Warning Signs.

a. RF warning signs are required to be posted at all access points to areas where levels exceed the PELs. Posting should be determined and maintained by the Safety and Occupational Health Office (SOHO).

b. Where 10 times the PELs are exceeded, other warning devices, such as flashing lights, audible signals, barriers or interlocks should be used.

c. RF protective clothing shall not be used as a routine method of protecting personnel from RF levels that exceed the PELs.

11-6. RF Safety Training.

USACE personnel routinely working with equipment that emits RF levels that may exceed the PELs shall receive training from the SOHO, addressing:

a. the potential hazards of RF,

b. procedures and restrictions to control RF exposures, and

c. their responsibility to limit their RF exposure.

Timely refresher training in RF safety shall be incorporated into other periodic safety training programs.

Table 11-1
Radio Frequency/Microwave Permissible Exposure Limits for
Controlled Environments

Part A-Electromagnetic Fields (f = frequency in MHZ)				
Frequency	Power Density, S (mW/cm^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Averaging Time E^2, H^2 or S (minutes)
30 kHz-100 kHz	102, 106	614	163	6
100 kHz-3 MHZ	102, 104/f^2	614	16.3/f	6
3 MHZ-30 MHZ	900/f^2, 104/f^2	1842/f	16.3/f	6
30 MHZ-100 MHZ	1.0, 104/f^2	61.4	16.3/f	6
100 MHZ-300 MHZ	1	61.4	0.163	6
300 MHZ-3 GHz	f/300			6
3 GHz-15 GHz	10			6
15 GHz-300 GHz	10			616,000/f$^{1.2}$
The exposure values in terms of electric and magnetic field strengths are the values obtained by spatially averaging values over an area equivalent to the vertical cross-section of the human body (projected area).				

Part B-Induced and Contact Radio Frequency Currents* Maximum Current (mA)			
Frequency	Through Both Feet	Through Each Foot	Contact
30 kHz-100 kHz	2000f	1000f	1000f
100 kHz-100 MHZ	200	100	100
* It should be noted that the current limits given above may not adequately protect against startle reactions and burns caused by transient discharges when contacting an energized object.			

Part C-Pulsed RF Fields		
Frequency	Peak Electric Field (kV/m)	Peak Power Density/ Pulse for Pulse Durations < 100 msec. (mW/cm^2)
100 kHz - 300 GHz	100	(PEL)(T$_{avg}$)/5 (pulse width)
Part D-Partial Body Exposures		
Frequency	Peak Value of Mean Squared Field (V^2/m^2 or A^2/m^2)	Equivalent Power Density (mW/cm^2)
100 kHz - 300 MHZ	<20*E^2 or <20*H^2	
300 MHZ - 6 GHz	<20*E^2 or <20*H^2	<20
6 GHZ - 96 GHZ	<20*E^2 or <20*H^2	<20(f/6000)0.25
96 GHz - 300 GHZ	<20*E^2 or <20*H^2	40

V^2/m^2: volts squared / meter squared = E (electric field) squared.

A^2/m^2: amps squared / meter squared = H (magnetic field) squared.

T$_{avg}$: average pulse time.

Table 11-2
Radio Frequency/Microwave Permissible Exposure Limits for
Uncontrolled Environments

Part A-Electromagnetic Fields (f = frequency in MHZ)				
Frequency	Power Density, S (mW/cm^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Averaging Time E^2, H^2 or S (minutes)
30 kHz-100 kHz	102, 106	614	163	6, 6
100 kHz-134 kHz	102, $104/f^2$	614	16.3/f	6, 6
134 kHz – 3 MHZ	$180/f^2$, $104/f^2$	823.8/f	16.3/f	f2/0.3, 6
3 MHZ-30 MHZ	$180/f^2$, $104/f^2$	823.8/f	16.3/f	30, 6
30 MHZ-100 MHZ	0.2, $9.4X105/f^{3.36}$	27.5	$158.3/f^{1.1668}$	30, $0.0636f^{1337}$
100 MHZ-300 MHZ	0.2	27.5	0.0729	30, 30
300 MHZ-3 GHZ	–		f/1500	30, –
3 GHZ-15 GHZ	–		f/1500	90,000/f
15 GHZ-300 GHZ	–		10	$616,000/f^{1.2}$

The exposure values in terms of electric and magnetic field strengths are the values obtained by spatially averaging values over an area equivalent to the vertical cross-section of the human body (projected area).

Part B-Induced and Contact Radio Frequency Currents* Maximum Current (mA)			
Frequency	Through Both Feet	Through Each Foot	Contact
30 kHz-100 kHz	900f	450f	450f
100 kHz-100 MHZ	90	45	45

> * It should be noted that the current limits given above may not adequately protect against startle reactions and burns caused by transient discharges when contacting an energized object

Part C-Pulsed RF Fields		
Frequency	Peak Electric Field (kV/m)	Peak Power Density/ Pulse for Pulse Durations < 100 msec. (mW/cm^2)
100 kHz - 300 GHZ	100	PEL)(T$_{avg}$)/5 (pulse width)

Part D-Partial Body Exposures		
Frequency	Peak Value of Mean Squared Field (V^2/m^2 or A^2/m^2)	Equivalent Power Density (mW/cm^2)
100 kHz - 300 MHZ	<20*E^2 or <20*H^2	
300 MHZ - 6 GHZ	<20*E^2 or <20*H^2	<4
6 GHz - 96 GHZ	<20*E^2 or <20*H^2	f/1500
96 GHz - 300 GHZ	<20*E^2 or <20*H^2	20

V^2/m^2: volts squared / meter squared = E (electric field) squared.

A^2/m^2: amps squared / meter squared = H (magnetic field) squared.

T$_{avg}$: average pulse time.